"TECH NOTES"

"TECH NOTES" is an effort by the Environmental and Engineering Program Materials Laboratory to share design and construction technology gained from projects or research performed. This issue is from the Pavements Branch discussing Longitudinal Joint Construction.

Longitudinal Joint Construction Techniques

Background

Distresses caused by poor longitudinal joint construction can result in the premature failure of multilane hot mix asphalt (HMA) pavements. These distresses are often in the form of raveling and eventually cracking (Figure 1). The cause is attributed to relatively low density and surface irregularity at the joint. Low density at the joint is not unusual since the edge of the lane first paved (cold lane) is unconfined. The subsequent lane (hot lane) has a confined edge and therefore tends to have a higher density, but still does not typically meet the minimum requirements. Because these irregularities exist, techniques for proper construction should be identified and used to ensure improved performance and longer lasting pavements.

Figure 1. Joint in Washington with raveling and cracking present.

A report titled *Evaluation of Eight Longitudinal Joint Construction Techniques for Asphalt Pavements in Pennsylvania*[1] is the primary source of information contained within this edition of TechNote. The report was produced based on findings from the Pennsylvania Department of Transportation (PennDOT) and the National Center for Asphalt Technology (NCAT). This study was done on 5 projects that were constructed in Michigan (1992), Wisconsin (1992), Colorado (1994), Pennsylvania (1995) and New Jersey (1996). This TechNote will concentrate on the Pennsylvania test sections with one additional joint construction technique used in Michigan and Colorado.

Construction of the Pennsylvania test sections was done in Lancaster County in mid-September of 1995. Each of the eight test sections were 500 feet in length and consisted of a 1.5-inch thick wearing course (see Table 1 for gradation) with ambient air temperatures ranging from 48 to 72°F. The overlap of new (hot) mix onto the cold lane was 1 to 2 inches with the idea that it would be luted so as to provide additional material at the joint to achieve higher density. However, this material was broadcast across the hot mat (up to 1½ feet) and therefore defeated the purpose of the overlap.

Table 1. Gradation for Pennsylvania mix.

Sieves	1/2"	3/8"	4	8	16	30	50	100	200	% AC
% Passing	100	98	68	45	25	15	11	8	5	6.0

Joint Construction Techniques

The eight types of construction techniques used in Pennsylvania include the following:

1. Joint Maker - Consists of boot-like device that is about 3 inches wide and is attached to the side of the screed, at the corner, during construction (Figure 2). The device forces extra material at the joint and a kicker plate lutes back the overlapped material so that raking is eliminated. The rolling was accomplished from the hot side with a 6-inch overlap on the cold lane (see technique 2).

[1] Evaluation of Eight Longitudinal Joint Construction Techniques for Asphalt Pavements in Pennsylvania. P. Kandhal, et al. July 2001. In 81st Annual Proceedings of Transportation Research Board, paper number 02-2451, January 2002.

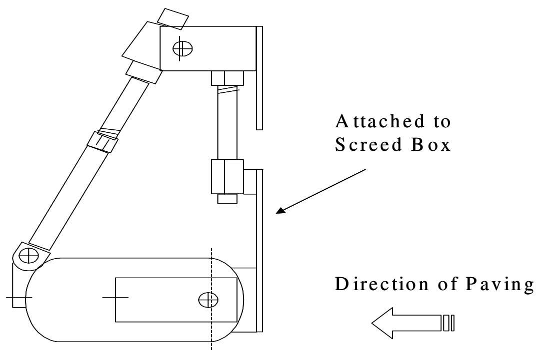

Figure 2. Joint maker.

2. Rolling From Hot Side - The initial pass was compacted from the hot side with a 6-inch overlap on the cold lane (Figure 3). The breakdown roller made 2 passes (forward and backward) in vibratory mode at this location.

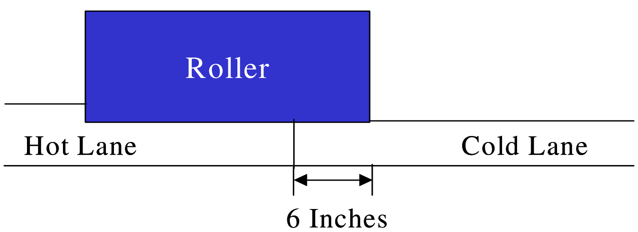

Figure 3. Rolling from hot side.

3. Rolling From Cold Side - Initial compaction was from the cold side with a 6-inch overlap on the hot lane (Figure 4). The first pass (majority of roller wheel on cold lane) was made in the static mode and the second pass (backward) was made in the vibratory mode with a 6-inch overlap on the cold lane.

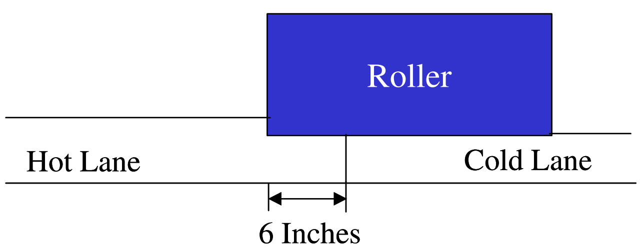

Figure 4. Rolling from cold side.

4. Rolling From Hot Side Away From Joint - Compaction began with the roller edge approximately 6-inches from the joint on the hot side (Figure 5). Both passes (forward and backward) were made in vibratory mode with the second pass overlapping the cold lane by 6 inches.

5. Cutting Wheel - This technique cuts 1 to 2 inches off the unconfined, low-density edge of the initial lane after compaction, while the mix is still plastic. The cutting wheel is place on the intermediate roller to produce a vertical edge, with higher density. The vertical edge was covered with an AC-20 tack coat prior to the placement of the second lane. Rolling was performed from the hot side with approximately 6 inches on the cold lane (technique 2).

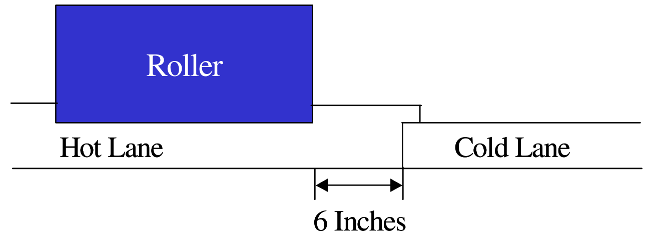

Figure 5. Rolling from hot side away from joint.

6. Edge Restraining Device - This device provides restraint of the hot-mix on the first lane of construction. A 3-inch wide wheel with a 45-degree bevel is attached to the breakdown roller. When the device is lowered, the roller passes within 6 inches of the edge and it offers restraint at the edge of the first lane constructed. Two passes in the static mode were made with this device. The breakdown roller then finished compaction, including the 6-inches not already compacted. The adjacent lane was then compacted following technique 2.

7. Rubberized Asphalt Tack Coat - A rubberized asphalt tack coat (Crafco pavement joint adhesive) was applied to the unconfined edge of the cold lane. The tack coat was approximately 1/8-inch thick. Rolling was performed from the hot side (technique 2).

8. New Jersey Wedge (3:1) - A wedge joint was created using a sloping steel plate attached to the inside corner of the paver screed extension (no compaction of the wedge itself). This formed a 3:1 taper while constructing the cold lane (Figure 6). The breakdown roller stayed 3 to 5 inches away from the tapered edge. The adjacent lane was placed with an infrared heater preheating the wedge to approximately 200°F prior to rolling from the hot side (technique 2).

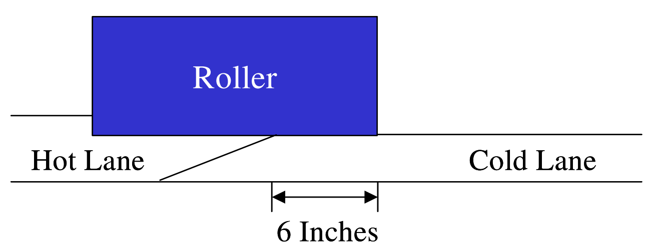

Figure 6. New Jersey Wedge (3:1).

The Michigan[2] and Colorado[3] projects utilized a step wedge joint (Figure 7), very similar to what has been used in Washington State over the past few years.

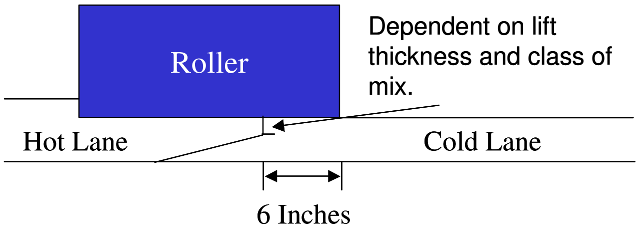

Figure 7. Notched wedge joint.

The Michigan project utilized HMA that had approximately 12 percent passing the 1/2-inch sieve and retained on the 3/8-inch sieve. The vertical offset was 1/2 inch and the taper was 12:1 (compacted with a small roller wheel attached to the trailing edge of the screed). The Colorado project utilized HMA that had approximately 17 percent passing the 3/4-inch sieve and retained on the 1/2-inch sieve. With the larger aggregate size, the vertical offset was 1 inch and the taper was 3:1. The adjacent lane was compacted according to technique 2 and the tapered face was tacked in both cases.

Test Results

Core samples were obtained at the joint and 12 inches from the joint on the cold side for the Pennsylvania project. Density determinations were then made, including the percent air voids. Table 2 illustrates the average air voids at the specified joint type.

Table 2. Percent air voids at the pavement joint.

Joint Type	Mean	Std. Dev.
Joint Maker	9.2	0.94
Rolling from hot side	10.3	1.49
Rolling from cold side	9.3	2.36
Hot side 6 inches away	10.0	1.29
Cutting wheel	8.7	2.16
Edge restraining device	7.7	1.78
Rubberized Joint Material	12.9	1.53
New Jersey Wedge (3:1)	14.8	2.15
Michigan Wedge (12:1)	8.8	---
Colorado Wedge (3:1)	9.2	---

Since construction, yearly evaluations were made, with the last visual performance evaluation made in July 2001. Performance data collected over this period of time, including the initial density measurements, has identified which construction technique resulted in the best functioning joint over time (Table 3).

Table 3. Six year field evaluation of longitudinal joints (organized by rating).

	Cracking			Raveling
Joint Type	Avg Rating	% Length	Avg Width (mm)	% Length
Rubberized Joint Material	9.88	0	---	2
Cutting Wheel	9.12	6	6.25	0
Hot side 6 inches away	8.75	6	3	8
New Jersey Wedge (3:1)	7.75	3	2	4
Edge restraining device	6.75	35	4.75	8
Joint Maker	5.50	85	9.5	0
Rolling from hot side	4.75	99	6.25	0
Rolling from cold side	4.62	88	9.5	0

Performance Observations

In the early stages, some of the joints appeared to perform better than others, regardless of density. As time progressed, environmental conditions allowed for several of the joints to worsen, especially during cold winters. The joints constructed by rolling from the hot side, rolling from the cold side, and the joint maker went from being rated as three of the top four in 1997, to the three worst in 2001, due to almost continuous cracking at the joint. On the other hand, the joints constructed with the rubberized material, cutting wheel, and rolling from the hot side 6 inches away were able to maintain a tight joint with minimal to no cracking and raveling.

Based on the six-year field performance of the different longitudinal joints constructed in Pennsylvania and relevant NCAT experience in Michigan, Colorado, and Wisconsin, the following ranks the techniques according to performance.

Longitudinal joints constructed using rubberized joint material (Figure 8) gave the best performance with no significant cracking, closely followed by the cutting wheel. However, the quality of the joint with the cutting wheel is dependent upon the skill of the operator.

The test section that constructed the joint by rolling from the hot side 6 inches away (Figure 9) and the New Jersey wedge also performed well with no significant cracking. However, the section with New Jersey wedge (without a notch) showed raveling 2 to 3 inches wide at the joint.

[2] Evaluation of Longitudinal Joint Construction Techniques for Asphalt Pavements. P. Kandhal, et al. Transportation Research Record 1469.
[3] Study of Longitudinal-Joint Construction Techniques in Hot-Mix Asphalt Pavements. P. Kandhal, et al. Transportation Research Record 1543.


Figure 8. Rubberized joint material.

The notched wedge joint, like that used in Michigan and Colorado, would have prevented the raveling and also allowed higher density at the joint (Table 2).


Figure 9. Rolling from hot side 6 inches away from joint.

Test sections using the edge-restraining device, joint maker (Figure 10), rolling from hot side (Figure 11), and rolling from cold side (Figure 12) developed cracking at the longitudinal joint anywhere from 35 to 99 percent of the test section.

Overall performance of rolling from the cold side resulted in a wider and deeper crack than compared to rolling from the hot side.


Figure 10. Joint maker.


Figure 11. Rolling from hot side.


Figure 12. Rolling from the cold side.

Conclusions
It is recommended that all rolling should be performed from the hot side, no matter which type of joint is constructed. This allows the use of a vibratory roller in the first pass and generally results in higher density. If just a change in roller operations is used, rolling from the hot side 6 inches away from the joint should be utilized. If a different type of joint is considered, using rubberized joint material and/or the use of a notched wedge joint (12:1), or a cutting wheel, will give the best overall performance in terms of durability.

The final recommendation is to specify a minimum joint density. Generally, this should be 2 percent lower than what is allowed for mainline; however, NCAT recommends that air voids be no more than 10 percent.

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